

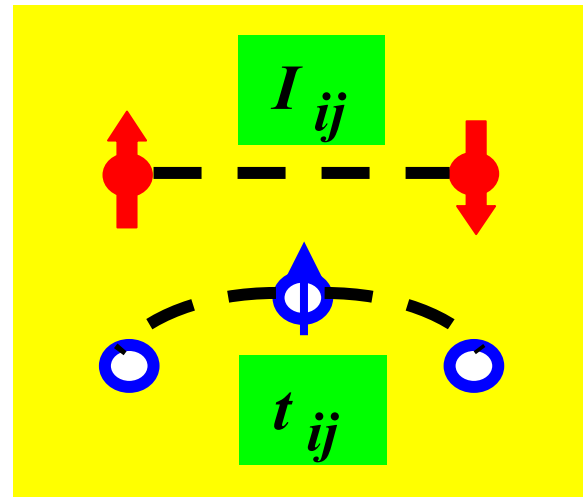
Quantum Phase Transitions and non-Fermi-liquid Physics

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- Matters have different phases, such as water, vapor, and ice; phase transitions occur when temperature is changed
- The Nobel-Prize-winning theory of critical points of thermal phase transitions, developed by Kenneth Wilson in the 1970s, is firmly based on the notion that critical excitations are infinitely extended in space
- Quantum phase transitions are entirely driven by quantum fluctuations, which in turn are dictated by Heisenberg's famous uncertainty principle
- For the past quarter of a century, it has been held that quantum excitations at a quantum critical point are infinitely extended both in space and time (Figure 2, Type II)

- We studied a model for heavy fermion metals (Figure 1)
- We identified a locally quantum critical point with excitations that are *local in space*, though still infinitely extended in time (illustrated by the vanishing of a local energy scale at the quantum critical point in Figure 2, Type I)
- The theory provides a natural explanation to some highly puzzling experiments in heavy fermions

Illustration of a model for heavy fermions, with spins and electrons



Quantum Phase Transitions and non-Fermi-liquid Physics (Cont.)

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The discovery of the locally quantum critical point has broad significance:

- It uncovers a fundamentally new type of quantum phase transition
- It represents a prototype for how strong quantum fluctuations and interactions lead to new quantum states of matter
- It provides new insights into the elusive physics of high temperature superconductors, the so-called non-Fermi liquid behavior

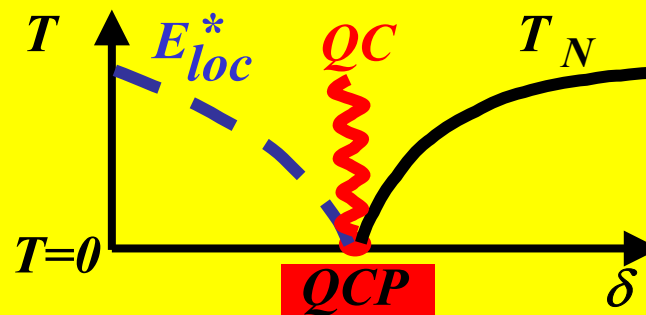
Junior researchers who participated in this work:

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Silvio Rabello (post-doc fellow)

Reference: Q. Si, S. Rabello, K. Ingersent, and J. L. Smith, Nature 413, 804 (2001)

Two Types of Quantum Critical Point (QCP)

Type I



Type II

